[JP,2003-178918,A]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]The thin film magnet with which this invention is used for minute devices, such as a micro motor and a micro-actuator, The rare earth thin film magnet which is excellent in especially magnetic characteristics is started, and it is related with the rare earth thin film magnet preventing oxidation of a rare earth permanent magnet film, and raising magnetic properties in the magnetic film which a nonmagnetic ground film, a rare earth permanent magnet film, and a nonmagnetic protective film are formed one by one on a substrate, and changes.
[0002]
[Description of the Prior Art]In recent years, slimming down of the magnet with which the miniaturization is demanded, therefore a motor and an actuator are also used is demanded with the small size and highly-efficient-izing of electronic equipment.
[0003]The rare earth permanent magnet which is excellent in magnetic characteristics is mainly used for these uses now, and if especially rare earth is set to R, the magnet of the presentation R-Fe-B [presentation] is written is used abundantly. However, since the magnet concerned was manufactured with powder-metallurgy processing, for slimming down further, it was a limit.
[0004]The research on thin-film-izing of said R-Fe-B system magnet has been activating for such a background inside and recently. For example, it has reported that Cadieu and others created the Nd-Fe-B thin film for the first time, and revealed magnetic properties (Vac.Sci.Technol., A6-1688 (1988)).
[0005]The magnet film which formed the rare earth permanent magnet film and Ti protective film one by one on the substrate which formed Mo board top or the Mo film with room temperature substrate temperature for the purpose of highly-efficient-izing more is also reported (JP,11-288812,A). The protective film of the magnet film in which the characteristic deteriorates easily is needed by oxidation.
[0006]
[Problem(s) to be Solved by the Invention]However, by the above-mentioned method, 10 nm - 100 nm of thickness with which practical use is presented as a protective film is needed. Such thickness means that time to form membranes becomes long, and has the problem that productive efficiency is low.
[0007]It not only raises productive efficiency, but this invention makes thin the protective film used for oxidation control of a rare earth permanent magnet film, and an object of this invention is to provide the method of also raising corrosion resistance by the same thickness.
[0008]
[Means for Solving the Problem]In order to attain the above-mentioned purpose, in this invention, a nitride which uses titanium as the main ingredients is formed in the surface of a magnet film as a protective film. That is, a rare earth thin film magnet of this invention is a magnetic film in which a nonmagnetic ground film, a rare earth permanent magnet film, and a nonmagnetic protective film are formed one by one on a substrate,

and said nonmagnetic protective film comprises a nitride which uses titanium as the main ingredients. Even if the film concerned is thin as compared with films, such as conventional titanium, it has an effect more than equivalent. A nonmagnetic protective film consists of titanium nitrides more preferably.
[0009]If a nonmagnetic ground film provided in an interface of a substrate and a rare earth permanent magnet film in this invention is constituted from a nitride which uses titanium as the main ingredients, oxidation of a magnet film by oxygen diffusion from a substrate, etc. can be controlled, and it is effective in the further thin-film-izing. A rare earth permanent magnet which uses neodymium iron boron (Nd-Fe-B) with big saturation magnetization and coercive force as the main ingredients can constitute a magnet film from this invention.
[0010]If a rare earth thin film magnet of this invention is applied to an actuator, since the protective film is thin, distance (magnetic gap) between a member which impresses a magnetic field of a magnet film, and a magnet can be made small. For example, in order to carry out self-hold of the driving member (a cantilever and mirror support part material) about MEMS (Micro-Electro MechanicalSystems) using ultra-fine processing technology or accumulation art, If a rare earth thin film magnet of this invention is used, a magnetic gap is small and power in which a magnet adsorbs a driving member can be enlarged. Since it is also possible to make thin thickness of a rare earth thin film magnet when [to require] fixed adsorption power is searched for, it contributes to slimming down and a miniaturization of MEMS. An optical switch, an optical path switching device, a micro machine device, etc. are contained in MEMS.
[0011]
[Embodiment of the Invention]When metal Ti is formed with a thin film, the surface oxidizes easily immediately for the activity character. Oxidation advances from the surface to a thickness direction, and when thickness is thin, it also oxidizes a rare earth permanent magnet film. Thickness must be thickened in order to inhibit the influence.
[0012]On the other hand, the material offered as a protective film of a magnet film by this invention is a nitride which uses Ti as the main ingredients. In order that Ti nitrides cannot oxidize easily and may not react to a Nd-Fe-B film, the magnetic properties are not degraded. However, in order to realize the compactness as a thin film, and crystallinity, the thickness more than fixed is required in thickness. In this invention, a thickness of not less than 10 nm is needed. Although a maximum in particular is not specified, at not less than 100 nm, there is no significant difference in an effect. However, when applying to actuators, such as MEMS, it is desirable for a maximum to be 100 nm from a viewpoint of membranous slimming down. Therefore, in this invention, suitable thickness shall be not less than 10 nm and 100 nm or less.
[0013]The protective film concerning this invention is formed by the producing-in vacuum-film methods, such as weld slag, ion beam deposition, and pulse laser ablation. If it is weld slag and the ion beam deposition method, a film will be produced by considering usual inactive gas as a discharge medium, and if it is the pulse laser ablation method, a film will be produced in a vacuum, but any method may be performed in a nitrogen atmosphere.
[0014]Ti nitrides in particular are not restricted to a 2 element-system Ti-N alloy, and a change does not have a part of Ti in the effect at the presentation replaced by metal, such as a little Ta, Si, and aluminum.

[0015]Ti nitride does not receive oxidation again, and since it is stable, it can use it as a ground film of not only a protective layer but a substrate, and a magnet film. When especially a substrate comprises oxides, such as glass, it controls that a magnet film oxidizes by the oxygen diffusion from a substrate, in order to reveal magnetic properties by heat-treating in a vacuum, after a Nd-Fe-B magnet film produces a film to the film production under high substrate temperature, or predetermined film constitution.
[0016]As for magnet film Nd-Fe-B, Nd is expressed with the presentation from which 13-15atom% and B become 7-11atom% and the remainder Fe. In adding other rare earth elements, it becomes the structure replaced by Nd, and the presentation of rare earth does not change at this time. The presentation should make the powder object magnet sample the calibration reference here, and EPMA should analyze.
[0017]The sample by which substrate temperature was produced one by one on the substrate like this invention at the room temperature reveals magnetic characteristics by heat-treating in the bottom of a not less than 600 ** elevated temperature, the inside of a vacuum, or anaerobic atmosphere. By producing a protective film and heat-treating a sample after that is describing the thing of the magnet film to do for a magnetic-properties manifestation to JP,11-288812,A. However, this technique is already art clear in the example of JP,9-237714,A, and is not special as processing for a magnetic-properties manifestation. Hereafter, according to an example, this invention is explained further in full detail.
[0018]
[Example](Example 1) Evacuation of the chamber in a film production device is carried out to below 10^{-8}Pa. By irradiating with a KrF excimer laser the target with which it was equipped in the chamber, a ground Ti layer, a Nd-Fe-B magnetic layer, and a TiN protective layer are produced one by one on the Si substrate which counters a target. TiN used the thing of the presentation to which a target presentation does about 50 atom % content of nitrogen. Nd-Fe-B used the target which serves as 13 and a 70 or 17 atom % presentation one by one. In all the film production, the irradiation energy of excimer laser controlled the frequency of 200mJ and a pulse generation to 10 Hz. Substrate temperature was made into the room temperature and the substrate was used as the MgO single crystal of the size of 10 mmx10 mm square. As for the ground Ti layer, 50 nm of thickness and Nd-Fe-B layers changed the thickness of the TiN protective layer here with 10-200 nm as 1 micrometer. After film production, the sample was taken out and heat treatment of 1 hour was performed at 700 ** under the vacuum environment below 10^{-4}Pa. The result of having measured the magnetic properties of the obtained sample with the oscillating-type magnetometer is shown in drawing 1. In the sample by which the ground film, the magnet film, and the protective film were formed one by one on the substrate, the graph of drawing 1 expresses the thickness dependency of the magnetic properties of the saturation magnetization Bs and the coercive force Hc about the case where Ti protective film is provided, and the case where the TiN protective film by this invention is provided. A round mark is Example 1 of this invention, and a triangle seal is the comparative example 1.
[0019](Comparative example 1) The sample was created also as that of the same conditions as Example 1 except having set the protective layer to Ti. The magnetic properties of the obtained sample are shown in drawing 1.
[0020](Example 2) 50 nm of TiN layers were formed as a foundation layer on the

substrate, the Nd-Fe-B film was formed by predetermined thickness after that, and 80 nm of TiN protective films were produced. A different sample was produced by changing the thickness of a Nd-Fe-B film within the limits of 100 nm - 1.5 micrometers. Other conditions produced the sample under the same conditions as Example 1. The measurement result of the magnetic properties of the obtained sample is shown in the same drawing 2. Drawing 2 shows the thickness dependency of the Nd-Fe-B magnet film of magnetic properties in the above-mentioned film constitution about the case where a ground film is TiN of this invention, and the case where 50 nm of Ti films of a comparative example are provided in **. A round mark is Example 2 and a triangle seal is the comparative example 2.

[0021](Comparative example 2) The sample was produced under the same conditions as Example 2 except having used Ti as a foundation layer. The magnetic properties of the obtained sample are shown in drawing 2.

[0022]As shown in drawing 1, when the result of Example 1 and the comparative example 1 is compared, the sample which has a TiN protective film in the range with a clearly thin protective film is excellent in magnetic properties. However, thickness serves as the almost same magnetic properties in not less than 100 nm. When the thickness of a Nd-Fe-B magnet film is thin, the effect of the improvement in magnetic properties is remarkable so that clearly from drawing 2 illustrating the result of Example 2 and the comparative example 2, when a TiN film is provided also in a foundation layer.

[0023]

[Effect of the Invention]These results show that a TiN protective film is more effective than the Ti film known conventionally. He can understand that not only a protective film but it is effective as a ground film. By composition of this invention, a protective film can be made thin, productive efficiency can be raised, and corrosion resistance can also be raised.

[Claim(s)]

[Claim 1]A rare earth thin film magnet which is the magnetic film in which a nonmagnetic ground film, a rare earth permanent magnet film, and a nonmagnetic protective film are formed one by one on a substrate, and is characterized by said nonmagnetic protective film comprising a nitride which uses titanium as the main ingredients.

[Claim 2]The rare earth thin film magnet according to claim 1, wherein said nonmagnetic ground film also comprises a nitride which uses titanium as the main ingredients.

[Claim 3]The rare earth thin film magnet according to claim 1 being the presentation for which said rare earth permanent magnet film uses neodymium iron boron as the main ingredients.

[Translation done.]

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